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RAMS FOR RAILWAY TURNOUTS

Abstract: The Specification and Demonstration of Reliability, Availability, Maintainability and Safety is an important issue for the integration of the railway system in the European Union. Rail's analysis of railways shows the necessity to design railway lines with the safety and accessibility of railways. RAMS needs to maintain on the railway line the unsatisfactoriness and rigidity of subwoofer and the highest quality of maintenance and operation.

Keywords: Rail RAMS; Quality of turnouts

The RAMS (Reliability, Availability, Maintainability, and Safety) procedure implemented on the Polish rail, including the specification of reliability (R), availability (A), maintenance vulnerability (M) and safety (S), contributes to improving the quality of services provided by railway managers. RAMS techniques consist of the following elements: analysis of the relationship between rail RAMS and the quality of services, RAMS components, factors affecting RAMS and the means to recognize them, risk and safety integrity [4].RAMS is a feature of the long-term operation of the entire railway system and its achievement by means of technical concepts, methods, and tools in the life cycle of the system. RAMS is a qualitative and quantitative indicator that the entire rail system or component of the rail system will function safely and accessible to managers and users. The goal of the railway system, which includes, among other things, infrastructure, rolling stock, control, energy is to achieve a certain level of rail traffic at a given time in a safe manner, RAMS describes the degree of safety assurance and affects the quality of the system delivered to the customer. The interrelationship of RAMS related to the rail is shown in Figure 1.

1. Interrelations of RAMS related to the rail

Availability according to RAMS is reliability in all possible failures, the probability of failure and the impact of failures on the operation of the system. Accessibility should be understood as maintenance susceptibility during scheduled maintenance, time for detection and identification as well as a location of failures and time for system repair and maintenance. RAMS security is all possible threats in the system in all modes of operation and maintenance and the seriousness of their consequences. The factors affecting RAMS are systemic, operational and maintenance conditions [4].

System conditions of reliability, availability, maintain compliance and security include the technical features of the rail system component [1]. Reliability of the railway surface is the probability of meeting the conditions imposed by it while maintaining its durability in time or under the design load. Reliability is also the probability that values of quantities defining its essential properties will not exceed the period within acceptable limits under given construction and maintenance conditions.

According to [3], the durability of the basic elements of the structure of the railway surface determined in the function of the transferred total load amounts to:

- for 60 E1 rail:
  - on the straight line it is 500 Tg,
  - on a curve with a radius of 300 meters does not exceed 130 Tg,
- for prestressed concrete sleepers:
  - on the sraight line 500 Tg,
- for the ballast - 250 Tg.

The intensity of rail wear in curves with a radius of 300 m corresponding to the radius of curves most commonly used in switches does not exceed 130 Tg, reducing the reliability of the turnout structure.

Durability of junction

Damage to the railway surface on the turnout length is more complex than damage on the sections of the track beyond it and proceeds much faster. Accelerated degradation of rails in the junction is caused by higher dynamic impacts of rail vehicles at places of discontinuity of tracks. In the switch section, the most dangerous damages are:

- non-adherence of the needle to the resistor,
- crumbling on the surface of the rolling spire and resistor.

In the part of the crossroads, faults and defects of the switch causing the necessity of introducing limited operation are:

- crushing the beak of the frog,
- cracking of the frog,
- run-off in the slot of the wing rails.

Concrete sanders in the crusher section are subjected to uneven dynamic load resulting in transverse cracks. The test results show that the increase in rail wear in the junction is caused, among others, by the change of the stiffness of the track structure between the track and the turnout [2]. The turnout is asymmetrical, it consists of moving parts that reduce the stiffness of the structure, and the density of the ballast under the turnout stays does not provide continuous support. The diversion carries an asymmetric dynamic load, especially in the cross-bending part, causing an uneven increase in vertical and horizontal deformations.

Availability of junctions

According to [4], the availability of a product that can perform the required function under given conditions at a given moment in time or within a given time span, assuming that the required external resources (including technical availability) are provided.

The availability of railroad turnouts according to RAMS should be understood as:

- reliability in the impact of failures of the turnout element on the functionality of the structure,
- maintenance susceptibility in terms of time needed for maintenance, diagnostics and repair,
- service and maintenance in the area of the whole turnout exploration cycle.

Safety of junctions

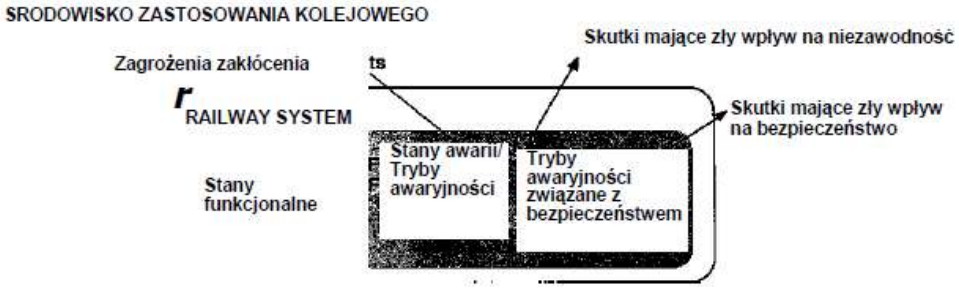
The safety of railway turnouts according to the RAMS is based on the knowledge of:

- threats to maintaining and operating the turnout,

- characteristics of each of the elements of the crossover and identification of the frequency of defects, damage to turnout elements,
- probability of occurrence of each type of failure in the range of switch control, mechanical failures and material damage,
- order, convergence, frequency of failure,
- susceptibility of the turnout structure to the ease of maintenance and repair,
- probability of error occurring during repair,
- time necessary for repair or replacement,
- availability of tools and equipment for crossover and repair diagnostics,
- an effective technique for dealing with diagnosed breakdowns.

Reliability of junctions

Failures of railway turnouts have a decisive impact on the safety of the entire railway system. Turnout failures affect the safety of traffic, limiting railway traffic, reducing the speed of traffic, punctuality of railway connections. Rail-oriented RAMS techniques in the aspect of turnouts affect the functionality of the railway system and the security of the systems used, the relationship between RAMS functionality and safety is shown in Figure 2.



2. Impact of failures in the rail system according to RAMS [4]

Reliability, availability, maintenance susceptibility and turnout safety, or RAMS related to the railway, are affected by three factors in Figure 3:
- **system conditions,** or sources of failure introduced into the system at any stage of the system life cycle,
- **operating conditions,** i.e. sources of failure imposed on the system during service,
- **maintenance conditions,** i.e. failure sources imposed on the system during maintenance operations.

3. RAMS impacts

In order to meet the requirements set by rail related RAMS, in particular with switches, requirements based on the precautionary concept should be met in order to minimize the likelihood of damage resulting from error during the life cycle stages.
In order to extend the life of turnouts, precautions are introduced, which are a combination of:

- **prevention**: regarding the reduction of the probability of damage,
- **protection**: to reduce the severity of the consequences of damage.

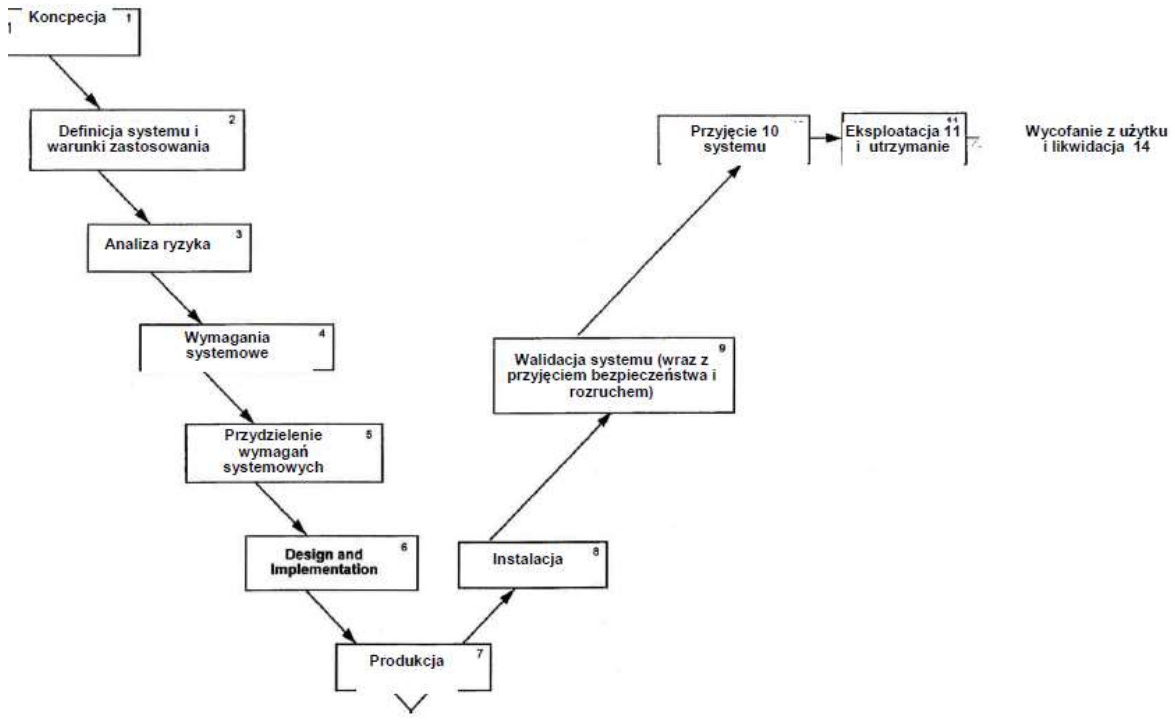
In the turnout life cycle, an inherent element are failures that, according to RAMS for the railway, were divided into three important, serious and minor categories presented in Table 1 together with the definitions of the norms.

Tab. 1. Categories of rail RAMS failures

Kategorie awarii	Definicja
Istotna (awaria unieruchamiająca)	Awaria, która: uniemożliwia ruch pociągu lub powoduje opóźnienie w usługach większe niż określony czas i/lub powoduje koszty większy niż określony poziom kosztów
Poważna (Awaria usług)	Awaria, która: - musi zostać usunięta, aby system mógł spełniać swoje określone funkcje i - nie powoduje opóźnienia lub kosztów większych niż minimalna granica określona dla awarii istotnej
Drobna	Awaria, która: - nie uniemożliwia systemowi wykonywania swoich określonych funkcji i - nie spełnia kryteriów awarii istotnej lub poważnej

The life cycle of the rail system

In the analysis of reliability, accessibility, maintainability, and safety of turnouts in the aspect of reducing the failure rate of glow elements and the entire structure. RAMS shows the system's life cycle in the right order. On the "V" type model, Fig. 4 shows the individual stages and relationships between them, which have an impact on increasing the life cycle of the turnout while maintaining the RAMS technique. The "V" model of the life cycle in the top-down branch (on the left) is a product development process and is a process of improvement resulting in the production of turnout components. The branch from the bottom to the top (right side) is connected with the assembly, installation, commissioning, and operation of the entire turnout system.



4. Model type "V" life cycle presentation for the rail system [4]

Focusing on point 11 related to the exploitation of the "V" type turnouts being the service and maintenance stage, one can notice a difference in general principles, and RAMS techniques in handling and maintenance procedures, which rely on general rules for:
- long-term turnout service,
- performing current maintenance,
- conducting current training in diagnostics and maintenance.

For operation and maintenance in accordance with the RAM (R-reliability, A-availability, M-susceptibility of maintenance) [4] should also be carried out:
- current implementation of orders for tools and spare parts,
- ongoing maintenance with an emphasis on reliability and logistic support.

According to [4] in order to preserve S-safety, the following elements should be introduced for point 11 of fig. 4 in terms of operation and maintenance:
- conduct ongoing security-focused maintenance,
- performance of ongoing security performance monitoring and maintenance of the hazard log.

On the example of point 11 from Fig. 4, the RAMS maintenance stage extends the scope of applied procedures in order to reduce the failure of the crossroads as a result of maintenance works and extending the durability of the structure.

RAMS in the Id-4 instruction

Procedures in accordance with the PKP PLK Instruction on Visual Inspection, Technical Testing, and Maintenance of Id-4 Turnouts introduce frequency of testing and inspection of turnouts and repairs. The Id-4 instruction does not take into account the maintenance procedure of the crossover with an emphasis on the reliability of the tested components, but only the identification and repair of damage. Lack of instructions for forecasting the occurrence of a failure in the Id-4 instruction depending on the type of turnout, forecasting failure due to the type of steel, crossbar, type of drive, fastening system, turnout type, makes it necessary to amend the regulations in order to adapt them to the standard requirements. Each of the elements of turnouts should be qualified according to RAMS techniques due to the frequency of failures, the possibility of predicting the occurrence of a failure. Analysis of forecasts is possible thanks to the introduction of a central register of damage to turnout elements divided into types of turnout construction, types of materials used and load class of turnouts in the reverse and main track. It is only the identification of the durability of the individual elements of the switch, frequency, and level of failure, which will allow you to choose the types of materials to ensure the safety of the railway traffic on the switches.

Summary

The RAMS (Reliability, Availability, Maintainability, and Safety) procedure implemented on the Polish rail, including the specification of reliability (R), availability (A), maintenance vulnerability (M) and safety (S), contributes to improving the quality of services provided by railway managers. The article presents the dependencies of the RAMS procedure related to the railway and the failure rate of the turnout and the length of the turnout life cycle in the aspect of the process of service and maintenance of turnouts. Analysis of procedures valid at PKP PLK Id-4 showed no guidelines as to the dependence of testing procedures, inspection, maintenance of the switch from the type of material from which the turnout is built. Materials used by turnout manufacturers differ in the durability of construction elements, which affect the reliability of the structure and trouble-free operation of the switch. According to RAMS, it is necessary to extend the inspection and maintenance procedure of the crossover to include

different types of construction materials in them in order to identify the frequency and extent of failures. Taking into account in the process of maintaining turnouts of the type of material used for the construction of the crossroads will allow for more effective diagnostics and more effective detection of failures, increasing the safety of the conducted railway traffic.

Source materials

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